DEMONSTRATING HOW THE APPLICATION OF TWO SELECTED STATISTICAL METHODS TO COVID-19 DATA CAN RENDER THE RESEARCH COMPONENT OF AN MSC ECONOMICS DEGREE PROGRAM AT A CARIBBEAN UNIVERSITY MORE MEANINGFUL AND UNDERSTANDABLE TO STUDENTS WHO SCORE HIGH FAILURE RATES ON ACCOUNT OF NOT HAVING A SOUND BACKGROUND IN STATISTICS

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Big data is a welcomed addition to the conventional field of the Sciences, coming at a time of increased volumes, having additional collection methods, diverse ways of manipulating and processing data using a variety of tools for undertaking analyses, graphical representation, and dissemination. New experiences confronting the global environment serve to widen the scope of pedagogy enhancing mode of delivery and giving many dimensions to data culture. In the context of COVID-19, the extensiveness of its impact is indicative of far-reaching consequences and data requirement to understand and manage its associated difficulties. In this paper, we demonstrate how practical applications of statistical procedures, as applied to the COVID-19 pandemic, can improve teaching and learning in a graduate Economics programme in the Caribbean. The paper provides some possibilities for syllabus construction to better prepare students of Economics for the world of research, academia and policy making using relevant data.

INTRODUCTION

Within the Caribbean context, data systems can be aggregated to give a regional picture that is in sync with the Big Data phenomenon. The characteristic features of large volume; diverse variety; speedy production and multiple sources are exemplified. Elevation into the domain of the Sciences (Data Science) signifies the important role that data has been assuming, a case being in the tragic circumstances being experienced regionally and globally. In this paper we use the COVID-19 Pandemic as an integral component in the redesign of an MSc. Economics programme being offered to students at the regional university serving Caribbean countries, with a particular focus on countries of CARICOM comprising 15 full member States and five others having observer status. Students enrolled in the programme, come from different countries and as such, the case study method is an ideal means of developing data systems that provide country specific as well as regional information.

The pandemic, being of multivariate dimensions, ideally imparts knowledge in the form of statistical data that is a foundational element of the discipline. It has brought about the need for extensive investigations and enquiries in order to arrive at answers to perplexing questions requiring workable solutions and in dispelling uncertainties and fears. Amidst it all, there remains the concern regarding, how and within what time frame it can be expected that there can be a return to a normal state of life. Since the COVID-19 pandemic has brought about immense loss of life within countries worldwide and remains a new and devastating encounter whereby issues pertaining to exposure to risk and hazardous encounters, the need to curb such behaviours, survival issues surrounding illnesses that have served as an underlying factor causing the sudden loss of lives, have created a need for extensive research and investigation. The uncertainties it has brought about contribute to a lengthy agenda for the search for knowledge and explanations to be an integral component of future teaching and learning curricula.

METHODOLOGY

We detail the possibilities of the use of such data in the methodology being outlined that is elaborated further in Table 4 that details the course content and outline. For the purpose of this paper, we show the application of COVID-19 data to model survival analysis by the use of life table method.

Survival Analysis and the Life Table Method

The COVID-19 pandemic has given rise to a perplexing situation that has warranted investigation involving patients who become gravely ill with the virus and died while others in a similar condition survived. This development has been of interest to researchers across the globe such as Filbin, Mehta, Schneider et al, of the Massachusetts General Hospital in which explanations are sought for this phenomenon that can certainly benefit the CARICOM countries. In addressing such a problem, students of the course will benefit from the opportunity of teaming up with researchers of the Medical Faculty of the Regional University that undertakes research into diverse conditions. This problem of an unexplained surge in deaths among COVID-19 patients from the perspective of utilizing data pertaining to patients medical histories, information about personnel characteristics such as age and sex, degree of access to health care services along with data on mortality, morbidity conditions, make for a research agenda that will enable students to become participants in research involving multidisciplinary teams across faculties working towards solving perplexing problems brought about by the COVID-19 pandemic, as these arise. Since, the pandemic has brought about devastating impacts in terms of extremely high mortality levels and the decisive role played by co-morbidities in bringing about mortality outcomes, the life table will provide measures and a better understanding of what these imply for future recovery.

In this paper, a simple illustrative example of survival analysis and the life table method is applied to COVID-19 data for one CARICOM country using the number of deaths and recoveries on a daily basis. From a methodological perspective, according to Barclay (1958), who has provided a set of methods for undertaking population analyses, "in order to justify all the trouble of learning the laborious steps of Life Table construction, it must have some distinct advantages over other measurement of mortality. The measurements are clear and unambiguous. They do not have conflicting messages and are in a convenient form." (Barclay, 1958 pp.124). Barclay (1958) further outlines ways in which the Life Table method can be utilized to provide survivorship measures, namely (a) in the description and summary of age-specific risk of death (b) in undertaking comparisons of such risks in different populations or population groups (c) in the construction of hypothetical models and (d) in making estimations which is the approach employed in this paper.

RESULTS: THE NEW COURSE CONTENT AND JUSTIFICATION

As an integral component of the course offerings, students are required to undertake research projects or coursework. Table 1 shown below provides statistics pertaining to the cumulative number of cases and deaths that have occurred within the CARICOM Region due to the COVID-19 pandemic over selected periods of time. These will constitute a data system to be continuously updated and disaggregated so that research activities pertaining to the virus can be carried out.

Table 1. CARICOM Population, Confirmed COVID-19 cases and deaths between October 2020 and 11, June 2021

All CARICOM Member States and Observer Countries	Population 2020 (World Bank Estimates)	Confirmed COVID-19 Cases Up to October 2020	Number of Deaths to October 2020	Confirmed Number of COVID-19 Cases as at March 2021	Number of Deaths as at March 2021	Confirmed COVID-19 Cases up to June 11, 2021	Number of Deaths June 11,2021
All Countries	18,881,476	36,198	745	107,463	2,048	170,875	3,366

Source: World Health Organization Weekly Epidemiological Update on COVID-19

Illustrative Example

The following serve as an illustrative example of results obtained utilizing disaggregated COVID-19 data for Trinidad and Tobago applying survival and life table analysis. Using a sample of 14-days (June 1-14), the number of daily cases, deaths and recoveries from COVID-19 were collated for Trinidad and Tobago (a CARICOM country showing the highest per capita deaths from the COVID virus. The censored variables were coded 1=failure or death and 0=withdrawn from study/recoveries following which survival analysis was conducted.

Table 2. Daily COVID-19 Statistics for Trinidad and Tobago (June 1-14)

Days	Cases	Deaths	Recovered
1	405	12	54
2	412	16	73
3	546	14	58
4	529	19	61
5	391	8	51
6	218	13	72
7	389	12	63
8	280	10	62
9	454	17	49
10	273	14	50
11	300	14	46
12	316	12	38
13	301	14	17
14	259	7	67

Source: Trinidad and Tobago COVID-19 (Novel Coronavirus) Update Media Releases

In Table 3 and Figure 1, the proportion surviving, cumulative hazard function and the hazard rates for the group of subjects are presented. Figure 1a shows the survivorship function which at the end of 14 days is 0.55%. The Hazard Rate plots (Figure 1b & C) shows that the hazard being experienced by individuals is changing over time. The question then becomes what the plausible explanation for this change may be. Essentially, it shows the increasing trend in the failure rate or deaths over the 14-day period.

Table 3. Standard Life Table Estimates

Time	Number Starting Interval	Number Lost/ Recovered	Number Died	Exposed To Risk	Cumulative Proportion Surviving	Proportion Surviving	Hazard Rate
0.7	943	54	12	916.0	0.98690	1.00000	0.01884
1.4	877	73	16	840.5	0.98096	0.98690	0.02746
2.1	788	0	0	788.0	1.00000	0.96811	
2.8	788	58	14	759.0	0.98155	0.96811	0.02660
2.1	788	0	0	788.0	1.00000	0.96811	
3.5	716	61	19	685.5	0.97228	0.95026	0.04015
4.2	636	0	0	636.0	1.00000	0.92392	

4.9	636	51	8	610.5	0.98690	0.92392	0.01884
5.6	577	72	13	541.0	0.97597	0.91181	0.03475
6.3	492	63	12	460.5	0.97394	0.88990	0.03772
7.0	417	0	0	417.0	1.00000	0.86671	
7.7	417	62	10	386.0	0.97409	0.86671	0.03750
8.4	345	49	17	320.5	0.94696	0.84426	0.07784
9.1	279	0	0	279.0	1.00000	0.79948	
9.8	279	50	14	254.0	0.94488	0.79948	0.08097
10.5	215	46	14	192.0	0.92708	0.75541	0.10811
11.2	155	0	0	155.0	1.00000	0.70033	
1.9	155	38	12	136.0	0.91176	0.70033	0.13187
12.6	105	17	14	96.5	0.85492	0.63853	0.22346
13.3	74	0	0	74.0	1.00000	0.54590	
14.0	74	67	7	40.5	0.82716	0.54590	

Source: Author created NCSS 2021 software

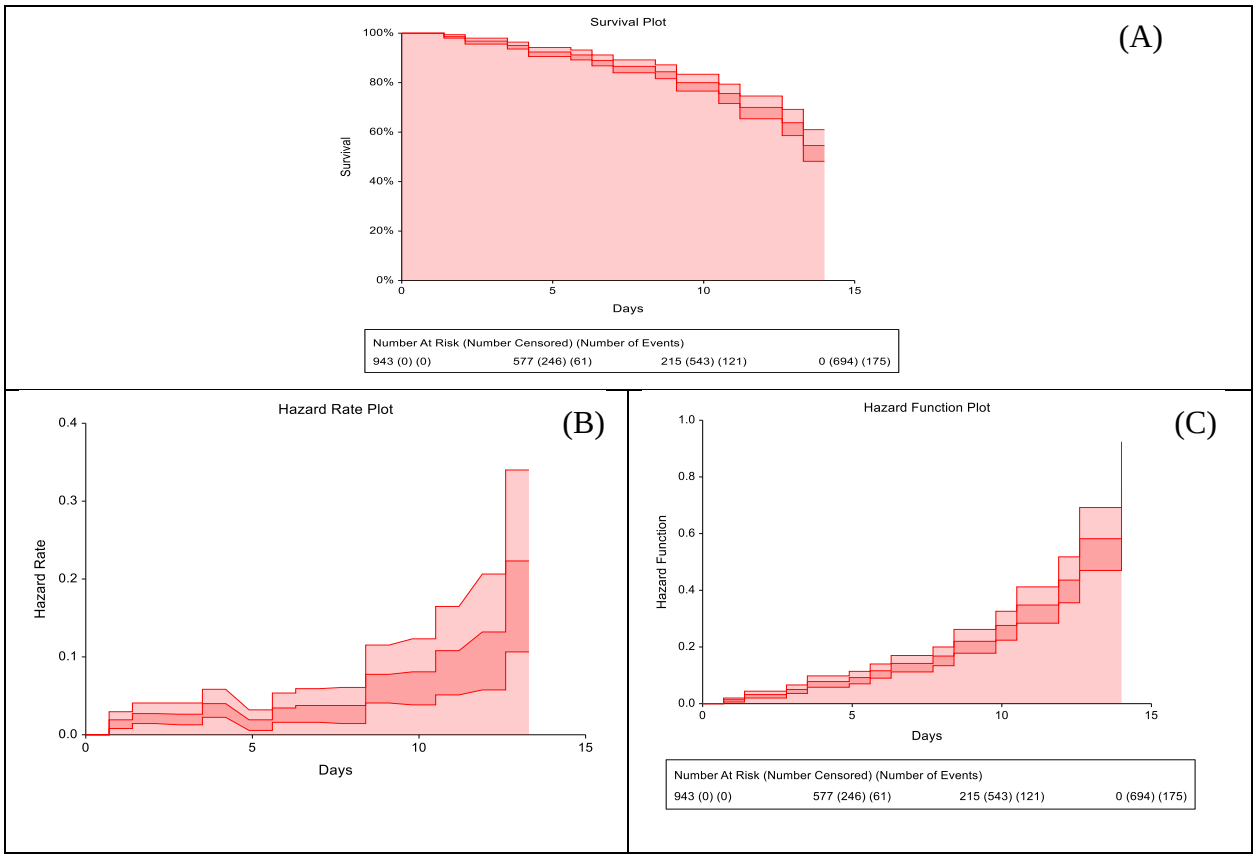

Figure 1. Survival (A), Hazard Rate (B) and Hazard Function (C) Plots for COVID-19 patients over (14 days)
Source: Author created NCSS 2021 software.

The results of the survival and life table analysis are particularly important for planning and building resilience. In the pandemic, information such as is provided through statistical models of this nature can help policymakers plan for in terms of health system capacity and the implementation of non-pharmaceutical interventions to mitigate the spread of the virus. Given the dynamic of the Caribbean in

which we are faced with issues of inefficient/weak health systems alongside limited resources, methodologies such as survival analysis can prove to be powerful planning tool.

Course Elements

Regarding the new design of the course structure, we propose the following items as an addition and upgrade to what now currently exist and the proposed survival and life table analysis (Table 4):

Table 4. Proposed New Additions to Course Structure

Topic	Justification
Digital approach to the delivery of health care	The COVID-19 experience has indeed given rise to the need for the adoption of new technologies in order to revolutionize the delivery of health care. On the occasion of the international conference on big data held on 31/08/2020, it was advised that "the use of new data sources and new technologies, such as Artificial Intelligence (AI) and Machine Learning, can make statistical operations more cost effective and provide timelier, more frequent and more granular statistical outputs. This is especially important to support rapid assessment of the COVID-19 situation and also to provide policy-supporting indicators for the 2030 Agenda for Sustainable Development." A perusal of several teaching programmes reveals examples that such developments have been taking place. According to the Harvard School of Corporate Learning, virtual teaching programmes do provide "knowledge, tools and strategies to design and implement technology aimed at bringing about changes in the delivery of health care.". (*Adapted from a Harvard Medical School Corporate Learning release*).
Spatio-Temporal Statistics	Spatial data science has been defined as being concerned with analyzing the spatial distributions, patterns, and relationships of data over a predefined geographical region. The COVID-19 pandemic presents an ideal situation in which data of a multidimensional nature can be used to capture the existence and spread of the virus. Representing data at small areal level significantly adds to the volume of the data stock. Given the number of countries that make up the CARICOM region, the representation of an extensive stock of spatial and temporally constituted data will be a valuable development.
Economic Statistics: Impact of the CORONA-19 Pandemic on the Economy	The impact of the CODID-19 Panic has severely impacted on matters pertaining to the economy such as: GDP earnings, employment, income generation and generally upon people's livelihood and way of living. Seeking to adjust to the new situation, populations have exhibited behavior patterns that have necessitated regulatory measures including: temporary closure or even shut down of businesses, loss of employment and even state of emergencies. Data pertaining to these economy related conditions must also be factored into the teaching programme design. A relatively new measure, that of the Disease Based Price Indexes, is much suited to the COVID-19 situation. The cost of sustaining economic life has proven to be immense and especially in seeking to meet the cost burden that the COVID-19 disease has brought about.

The Cox Proportional Hazardous Model	The *Cox proportional hazards model* has been widely applied in undertaking studies involving relationships between sets of explanatory variables being observed over specified periods of time. As described in the literature consulted, "it enables the investigator to study relationships between the time to event outcome of Y and a set of explanatory variables $\mathbf{X_1, X_2, \ldots, X_p}$". The CORONA-19 Pandemic has given rise to an extensive set of factors (variables) that are to be featured in carrying out investigations. The stock of data is yet in its infancy but in time will enable it to be used for the determination of survivorship within populations and in undertaking comparative analyses. Covariates that account for survivals can be readily identified and according to the methodological literature, "once regression coefficients have been estimated, it is possible to provide estimated survival curves for persons with different constellation of covariate values."

CONCLUSION

The approach proposed in this paper draws upon experiential teaching and learning and authentic assessment in which students replicate the tasks and performance requirements typically expected and found in the world of work for a graduate in economics. The incorporation of Big Data and practical examples in the teaching of economics promotes students' involvement which enhances the learning process. The distressing experience of countries due to the COVID-19 pandemic would serve to greatly sensitize students to statistical methods that can be applied in such a context. To this end, we believe that real-world applicability would significantly improve syllabus construction, delivery and learning outcomes for students. Its application to the countries of CARICOM will more readily appeal to students, given the fact that they can identify with or have familiarity with the operations of this social space and environment.

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